GROUP JUDGMENT TECHNOLOGY

Principal Investigator for ARPA CCBS Project: Gerald H. Shure

Project Leader: Norman C. Dalkey
Co-Project Leader: Gerald H. Shure

SCOPE AND OBJECTIVES

The basic aim of the Group Judgment Technology project is
the development of improved procedures for the use of expert
judgment as an aid to government and industrial decisionmaking.
The area of potential techniques is wide, extending from simple
polling of groups of experts to the complex and structured inter-
actions involved in simulation and gaming exercises.

Similarly, the factors that determine the effectiveness of
group judgment procedures for decisionmaking cover an equally
broad range. No comprehensive taxonomy for these factors has
been developed. Among the most important factors are: (a) the
type of subject matter appropriate for group judgment procedures,
(b) the characteristics that determine expertise and their
measurement, (c) the aspects of group interaction that affect
performance, (d) the structure of the estimation task posed to
the group, (e) the role of external sources of information, (f)
the physical environment of the exercise, including communication
facilities.

PREVIOUS EXPERIMENTAL RESULTS

Previous experiments, including the ARPA-sponsored series
at Rand and a number of experiments by social psychologists over
the past 50 years, have shed considerable light on some of these
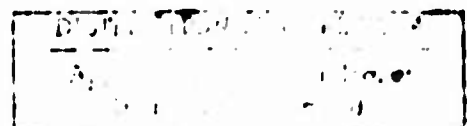
factors. The appended list of references contains the most relevant studies. Major findings, many of which are based on ARPA-supported Delphi studies, include: Delphi procedures are most appropriate where the best information available is the judgment of experts, i.e., where good data and well-validated theories do not exist, and where, for problem solving tasks, there is no objective way to monitor progress toward a solution. This excludes a large number of cognitive tasks such as solution to mathematical problems, state-of-the-art design of equipment, and the like.

A large number of experiments have shown that for the appropriate judgmental tasks, there are large advantages to pooling the estimates of a group ("n heads are better than one" rule). These advantages include: the group response will generally be more accurate than a representative individual response, and the dispersion of the group responses is a valid indicator of the accuracy of the group [1,2,3]. Most of the desirable formal properties of group judgment carry over to value judgments (goals, objectives, priorities). [4]

Studies evaluating the usefulness of group judgments on highly uncertain questions for "real-life" decisionmaking are rare. Dr. John Williamson at Johns Hopkins has been investigating the usefulness of Delphi procedures for generating information concerning the state of health of the general public as inputs to HEW policy formulation [5]. Most of the information available on this question consists of intuitive judgments by decisionmakers on whether Delphi studies conducted in their organizations were "useful".

Information on the characteristics of expertise is some-
what fragmentary. The two most significant components appear
to be amount of relevant background information and estimation
skill. Low, but statistically significant correlations have
been found between accuracy of estimates on short-range fore-
casting questions and scores on standard achievement tests [6]
as well as with scores on standard intelligence tests [7]. A
conceptual level score (Paragraph Completion Test) appears to
be related to degree of certainty (spread between low and high
estimates) of respondents [8]. There is some evidence that
estimation skill can be improved with short training sessions
[9]. Self-rated competence (on a given question) has shown small
but statistically significant correlation with estimation accuracy
[10]. There is some evidence that performance is related to
"cognitive style" e.g., students from the hard sciences perform
less well than those from the social sciences. In general,
women perform less well on estimation tasks than men [11]. More
specifically psychological parameters such as motivation, personality
traits, and task perception have received only cursory attention.

A cognate practical issue relates to the selection process
for experts for a specific study. The usual selection process
(nomination by peers) is probably subject to a number of biases,
including the tendency of individuals to nominate experts whose
opinions agree with their own [12]. Bias-reduction techniques
have been studied as part of a projected extension of the
Johns Hopkins study, but have not yet been tested experimentally.

Most of the relevant work on Delphi procedures has been
aimed at identifying improved methods of group interaction.
The early emphasis on anonymity of response, iteration, and
controlled feedback, was based on intuitive "fixes" to
informally observed problems with face-to-face interaction--
biasing effects of dominant members, group pressure and band-
wagon effects, irrelevant communication ("noise"). Experiments
comparing anonymous feedback interaction with face-to-face
interaction conducted at Rand in 1967-68 indicated a slight
superiority for the anonymous feedback mode [11]. Subsequent
experiments have shown that much larger improvements can be
obtained with other parameters--group size, additional informa-
tion, selection of more competent subgroups on the basis of self-
ratings, statistical compensation for biased estimates (e.g.
use of the 63rd percentile instead of the median). Two recent
results are that a statistical group response is an effective
way to pool diverse information within the group (without
information transfer) and that a basic feature of the group
estimate, the ratio of log-error to the standard deviation, is
invariant over wide ranges of relevant input information [13].
These may open up an entirely new perspective on the significance
of group interaction, e.g., that part of the poor showing of face-
to-face interaction is due to the minor effect on accuracy of
information transfer.

Basic understanding of the estimation process itself is
spotty (some of this will be treated in Section 3). A number
of significant features of the process--log-normal distributions

of responses, general tendency to underestimate uncertain
numbers, short optimum response time, nonlinear increase in
error with size of number estimated--have been relatively
well established by the experimental data, but have not yet
received satisfactory explanations.

Other components of the structure of the estimation
task that have received attention are the feasibility and
usefulness of probability estimates [14], the relation between
question length and a measure of precision of response [15].

The role of external sources of information as feed-in
to a Delphi exercise has been studied in a series of experiments
at Rand. These have indicated high improvement in accuracy as
a consequence of feed-in of additional "hard" factual information,
and a decreasing return for each additional piece of information
[13].

Experimental study of the role of the environment, including
the characteristics of the communication system has not been
pursued for the kind of subject matter appropriate for Delphi
treatment. There is a fairly large literature dealing with
these topics for related tasks (e.g., Bavelas, Guetzkow and Simon;
and Shure, Rogers, et al., experiments with communication nets for
well-defined problem solving tasks) [16].

SCOPE OF APPLICATIONS

Although the amount of effort going into experimental
evaluation of group judgment procedures is small, the amount
of effort being expended in applications is quite large, and
is still expanding rapidly. The major applications have been
in the industrial area with the forecasting of long-range
technological developments as an aid to industrial planning.
The list of industrial contractors that have initiated studies
of this sort is extensive. It includes companies such as TRW,
Smith, Kline and French, IBM, Xerox, General Motors, McDonnel-
Douglas, Martin-Marietta, and many others. In a recent survey
of long-range forecasting activities in the United States by
John McHale at the Center for Integrative Studies at the
State University of New York at Binghamton, [17] Delphi was listed
as the second most utilized technique for long-range studies
by industry, where well over 40% of the organization reported
that they had made use of it. The same ratio was observed in
a very large survey of industrial organizations and research
organizations conducted by Marvin Cetron. Out of about a
thousand returns, something of the order of 40% said that they
had utilized Delphi for one type of study or another. The
Institute for the Future, founded by Olaf Helmer, has in the
past three years conducted roughly fifteen extensive Delphi
studies for both industry and state governments, dealing with
long-range forecasts of technological and social events.

The activity has spread to practically every country
on the globe. There have recently been a number of reports

of studies from behind the iron curtain. One of the most
impressive of the foreign efforts is the study recently
completed for the Japanese government which utilized 4000 of
their top scientists and engineers to generate technological
and social developments as inputs for government planning.
They are now in the middle of Phase II of that study, in which
they are attempting to answer the question how the set of
forecasts can be brought to bear on the design of government
policies.

In the United States the federal government has been a
little slow to initiate Delphi-type studies. But at the present
time there are perhaps 30 studies by different government agencies
which are in process or have recently been completed. The CIA
has at least four activities under way; one is a study of manpower
requirements and training; another is a study of Soviet objectives
for the Future Threats branch; Delphi is being employed as a
component of their advanced analyst training course, and is being
investigated for applications to estimates. DIA last year
conducted a large-scale allocation exercise using Delphi to--among
other things--rate a set of pertinent objectives. The Naval
Ordinance Laboratory recently completed a rather extensive study
of future undersea requirements. All three of the services
have several studies under way involving items such as evaluation
of tactical targets and reliability of future weapons systems.
Nonmilitary government agencies which have employed Delphi
studies include the Office of Emergency Planning, the Coast Guard,
Department of Transportation, Internal Revenue Service, and the

Forestry Service.

The area of subject matters to which Delphi studies have
been applied has also expanded. Topics that have been studied
include items such as the reliability of hardware and equipment
still in development, the rating of corporate objectives,
acceptable weather conditions for paradrops operations, and
identification of potential educational innovations. An
interesting merging of Delphi technique with public opinion
survey techniques has been used by a number of research centers
for the generation of objectives for elementary education [18].
In fact it is difficult to find any area of direct interest to
decisionmakers where Delphi has not been tried.

PROPOSED RESEARCH AREAS

All of the factors listed under SCOPE AND OBJECTIVES warrant
further study. However, since the primary aim of the present
project is primarily technological--i.e. the development of
improved procedures--some of the potential areas of research look
more promising than others with respect to likelihood of fairly
immediate return in experimental results and usefulness of those
results for practical applications. In addition, the special
capabilities of CCBS opens opportunities for the development of
much more effective group judgment processes than have been employed
up to now. The areas of research that appear most promising are:

1. Experimental Studies of Delphi Methodology

Several aspects of the estimation process and the formulation
of group responses are of direct importance for applied studies

of the sort now being conducted in government and industry. These include:

(a) <u>Combination of Accuracy Measures</u>. In previous experiments, the dispersion of the group distribution of responses, and the average of individual self-ratings of competence have been demonstrated to be valid indicators of the accuracy of group response (median). These studies have dealt with responses to individual question. In practical applications, group judgments are obtained on a complex, interacting set of questions, where the responses are combined to produce conclusions of interest to decisionmakers. What little evidence is available suggests that the dispersion and self-ratings do not combine in a normal statistical fashion. The experiments will involve obtaining answers to a given set of questions in several ways--direct estimation, estimation of relevant factors and computing the answer from these, combined estimation of questions and relevant factors. The data will give a clearer indication of the way in which the accuracy indices should be combined in applications.

(b) <u>Group Probability Judgments</u>. Experiments to date indicate that it is feasible for subjects to produce probability distributions as responses to uncertain questions, and that a summed distribution will score higher on a probabilistic scoring system than on a distribution of point estimates [14]. This set of experiments will extend the investigation to a wider set of questions, particularly cases of greater uncertainty, and in addition examine the effectiveness of self-ratings for the

selection of more knowledgeable subgroups in the case of probability judgments.

(c) Level of Detail. In most applied exercises there is a tendency to "unpack" decision problems to a high level of detail. Group judgments are then obtained on the many elements of the detailed analysis. There is no good experimental evidence that this is either the most effective way of obtaining the most accurate answers to questions which are directly relevant to decisionmakers' interests nor that this is the most efficient way to use the knowledge of expert advisors. The experiments will test the accuracy of answers generated by models at several levels of detail to see if there is some optimum level, and to identify, if possible, the characteristics of the problem on which the optimum level depends.

(d) Bias Correction Techniques. There appears to be a general tendency for respondents to underestimate uncertain numbers. Over a very large number of responses obtained in previous experiments, an average improvement of about 30 percent in the log error is obtained by using the 63rd percentile as the group response rather than the median. The error in this case appears as a bias; it is much larger than would be expected from sampling theory alone. We are comparing several models of the estimation process with the data to see if a firm theoretical base can be identified for the 63rd percentile correction factor.

2. Analytic Developments

In order to make Delphi techniques more responsive to the needs of practitioners, several analytic capabilities require extension. Three which are of immediate practical value are:

(a) Extension of Probabilistic Scoring Systems. Probabilistic scoring systems are among the more powerful tools for investigating both individual and group probability judgments. To date they have been devised for a relatively simple type of judgment--namely the single forecast with either a probability distribution over a given quantity, or a finite set of complete and exhaustive alternatives. To be applicable to more complex types of judgment, the formalism must be extended to other forms of probability statements, especially to the case of relative probabilities.

(b) Cross-impact Analysis. One of the more promising procedures for long-range forecasting of technological and social events is cross-impact analysis--a technique for taking into account the interrelations of events in assessing their probability of occurrence. As developed at the Institute for the Future, the technique has suffered from logical flaws that have made application to the technique to practical forecasting studies questionable. Considerable progress in furnishing a sound logical foundation for the technique has been made in recent work at Rand [19]. This work will be pursued, both to furnish a meaningful decision structure for applications, and to furnish a useful framework for later experiments with on-line model construction.

(c) Dimension-reduction Techniques. One of the basic difficulties which arises in application is the "point-of-view"

problem. For most decision situations, each expert has "in the back of his mind" a crude model consisting of a blurred list of the most important factors as he sees them, along with a rough feeling for the interactions among the factors. These "models" can differ widely among experts--expressing their specialized backgrounds and personal cognitive styles. A Delphi exercise can be used to elicit these partial models, but in order to aggregate them into a coherent "group model" rather powerful techniques of collation and clustering are required. Multidimensional scaling and hierarchical clustering routines have proved to be useful for elementary aggregation of panel-generated lists of corporate objectives for example; but these techniques need augmentation in several directions before they can be considered satisfactory for on-line modeling. In particular, there is a need for integrated display and group-editing procedures. The basic capabilities probably already exist in the CCBS system, but a fair amount of experimentation will be required to configure procedures for efficient use by expert groups.

3. Extending the Scope of Delphi Capabilities

Up to now, experimentation has mainly been concerned with elementary group judgments, i.e., with the formulation of group responses on single, well-defined questions. In practice, decision problems involve complex, interrelated judgments. To make the benefits of the experimental program of maximal value to decisionmakers, it is necessary to extend the evaluation of procedures of group judgment that are appropriate for more realistic (and hence more complex) decision problems.

(a) <u>Integrating Delphi and Decisionmaking Structures</u>. It
is very likely that the volume of Delphi studies for a wide
variety of decision problems will increase rapidly over the next
few years in state and local governments, in the federal government
and in research institutions. There will probably be a shake-out
with regard to the elementary type of Delphi study exemplified by
the identification of technological developments in a given area
and estimates of the time of occurrence and some estimate of the
relative importance. By and large this kind of study has turned
out to be of peripheral interest to decisionmakers and not directly
relevant to policy formulation. The most successful studies have
been those which have been formulated directly within a decision-
making context where the implications for policy were defined
ahead of time. Representative cases are the use of Delphi by
Corning Glass [20] to select development projects and the DIA
study mentioned earlier. There will be a general increase in
studies of the sort where the Delphi exercise is an integral part
of the decision process, involving the formulation of corporate
or agency goals, the identification of major policy options
and the estimate of the impact of each policy option on the set
of goals. Such a structure, for example, would find a direct
application in budget allocation problems.

Experiments to evaluate the appropriateness of Delphi
procedures for generating and rating objectives have been
conducted with favorable outcomes [4]. Relevant experiments

with a more complete decision structure in which potential
careers were rated against a set of personal objectives also
indicate that group ratings on objectives are more reliable
predictors of individual choice than individual ratings [21].
However, careful experiments to pin down the range of appropriate-
ness have not been conducted to date.

(b) <u>On-line Model Construction</u>. One of the unexploited
capabilities of Delphi is its use for the generation of models.
As noted under the section on dimension-reduction techniques,
experts usually have partial models of the decision situation
"in the backs of their minds". These can be elicited by Delphi
techniques, and an aggregated group model derived. For applied
studies it is not necessary that a completely formalized mathematical
structure be generated. The group acts as a kind of model in that
it can integrate an extensive amount of information on its own.
What is required is that the structure of the decision problem be
specified sufficiently that subsequent group estimates are
directly relevant to the pertinent decision issues. This was in
outline the process pursued in the first Delphi study at Rand that
used systematic group procedures with iteration and feedback [22].
At present, if this process is conducted by the usual questionnaire
technique--especially with geographically dispersed panels--time
lags are likely to be excessive. On-line interaction can
drastically reduce time lags, and at the same time allow preliminary
computations with initial versions of the model as a basis for
subsequent revisions. Needed are techniques for collating and
structuring the natural language responses typically obtained

in the opening rounds of a model identification exercise.

(c) <u>Improved Interface with Formal Decision Models</u>. At
present, formal decision models such as optimal budget allocation
techniques, cost-benefit models and the like do not mesh well
with group judgment techniques. The primary reason is that
with Delphi procedures it is generally feasible to obtain estimates
concerning a wide range of parameters not normally included in
the formal models, especially items of the sort usually labelled
"intangibles". Techniques are needed to extend the formal models
to include this wider range of information.

4. Adapting the Capabilities of CCBS

The extensive on-line facilities available through CCBS
will make experimentation with complex decision structures much
more feasible than in the past. In addition, these facilities
can operate as a test bed for on-line decisionmaking procedures
of a sort likely to become widespread during the next decade in
both governmental agencies and industrial corporate management.
The advantages of on-line computer systems for group interaction
are clearly quite large. They include, among others, the very
great time compression that can be achieved, along with the
possibility of geographic dispersion of the panel. In addition
there is the ability to deal with very large volumes of data, which,
for example, allows the possibility of large panels of respondents,
but also large numbers of responses from each panelist. There
also is the possibility of the group interacting with extensive
data banks and the possibility of sophisticated computation as
an integral part of the ongoing exercise. The elementary Delphi

laboratory at Rand was one exploratory activity in this area.
Murray Turoff at OEP has tried an exploratory exercise with a
geographically dispersed group, utilizing a time-sharing system, [23]
which had the rather significant spinoff that it enabled the rapid
creation of an on-line information system to implement the recent
wage/price freeze. The Plato project at the University of Illinois
has explored several aspects of man-model interaction [24]. A
number of other exploratory exercises are going on throughout the
country, primarily directed toward the development of on-line
conferencing systems.

(a) **Software for Delphi Experimentation.** The laboratory
configuration with 24 stations and highly flexible data acquisition,
analysis and communication capabilities is ideal for Delphi
experimentation. Programming the requisite query routines, feed-
back data displays, and intra-round analysis should be highly
efficient using the LIS capability [25]. In addition to these
"standard" elements of a Delphi exercise it will be possible to
develop routines for collecting nonnumerical responses, and
processing these in terms of emendation by the group.

(b) **Interaction with Data Bases.** Previous experiments have
demonstrated a large improvement in accuracy when precise,
relevant information is available at the time the estimates are
being made. One of the capabilities inherent in the CCBS configura-
tion is rapid access to extensive data files, and on-line explora-
tion of these via the TRACE system [26]. Another is the capability
of real-time augmentation of such files by direct input from
experts, either individually, or as group judgments. Thus the

files allow feed-in of information from external sources, inter-
change of information among the panelists, and mutual evaluation
of the information.

(c) **On-line Delphi Exercises.** Present questionnaire
techniques for conducting Delphi studies result in long lag
times (typically up to six months for a three-round study). Part
of the lag time results from delays in the mail, part from
processing delays (key-punch, batch processing, etc.). Most of
this delay can be eliminated by using an on-line system for data
acquisition and processing. On-line Delphi studies with
geographically dispersed panels can be run shortly after the
elementary Delphi software is implemented. However, these would
be relatively simple exercises with preprogrammed questions. To
conduct more sophisticated studies in which, e.g., the panel could
formulate its own questions requires some of the additional
capabilities discussed above. On-line exercises with geographically
dispersed panels will be possible with much greater economy and
more extensive capabilities when CCBS is integrated into the ARPA
net.

5. Studies of the Estimation Process

In addition to the study of complex judgments, there is good
reason to believe that basic improvements in Delphi procedures
can be made by obtaining a clearer understanding of the estimation
process itself. The intent here is to identify and "calibrate"
the elements or "phases" of the process of producing a numerical
estimate. It seems probable that when a subject is requested to
furnish an answer to a question, at least four separate activities

take place: (a) ingesting and understanding the question, (b)
memory search for relevant information, (c) evaluation of this
material with respect to relevance and validity, (d) generation
of a numerical estimate based on acceptable information. These
activities can be replicated in feedback loops several times
before a final judgment is expressed. For example, evaluation can
lead to further search for useful information; an unexpected
estimate can lead to re-examination of the question--"Did I under-
stand it?--and the like.

The long-range interest here is whether these activities can
be experimentally defined, and usefully quantified. One basic
quantification is afforded by time, i.e., the time to carry out
the activity. Time dissection will require experimental techniques
that are only partially developed at present; but there is reason
to believe that with the CCBS system available techniques will
evolve as data accumulates.

Primary emphasis in the studies will be placed on those
characteristics of the estimation process which are relevant to
the efficiency and accuracy of the estimate. It seems rather
likely from informal observation that much of the information
generated by the memory search activity is not only irrelevant,
but also biasing. The time vs. accuracy result indicates that
something in the process is quickly saturable; this could be the
number of pieces of information that can be usefully handled by the
generation process, or simply the number of items of information
that can be kept in mind at one time (George Miller's "Magical
number seven"). Without prejudging the experiments, it appears

likely that understanding this saturation phenomenon could lead
to basic improvements in estimation procedures.

Initial experiments will involve a more careful set of
timing studies, where, to the extent possible, parts of the
process will be bypassed. Exploratory sessions have been run,
where the subjects are told beforehand the kind of question
that is to be asked, and respond to a single word or short phrase.
Initial investigations have shown very short estimation times
when the subject is instructed to write down the first number that
comes to mind as an answer to the question. In general, about
two seconds is required to read the name and form an initial
estimate. Comparison runs, where the subject is presented a
number and simply asked to write down that number, indicate that
possibly one half of the response time consists in reading the
item and preparing to write down a response.

RESEARCH PROGRAM

To assure the achievement of these capabilities, a relatively
long time horizon must be assumed. Three years appears to be
about the minimum needed to progress from the elementary procedures
now available to the integrated on-line decision process appropriate
for the later '70's. In the research program described below,
activities for fiscal '73 are specified in some detail. Activities
for the following two years are sketched with somewhat less detail
since they will depend to some extent on the results of the first
year's investigations.

1. Research Proposed for Fiscal '73

The research which is proposed for the coming year is relatively narrow in scope and aimed at obtaining experimental results that will be of immediate and direct use for present generation applied studies. Thus, the activities will consist mainly of setting up the CCBS facility for running Delphi exercises, and carrying out the set of experiments listed under Experimental Studies of Delphi Methodology. A small part of the effort (about 10%) will be expended on continuing the analytic work on probabilistic scoring systems and cross-impact analysis. Another fraction of the effort will be expended in developing the on-line collating and group editing procedures discussed under On-Line Model Generation and relating these to appropriate dimension-reduction computations (cluster analysis to begin with).

2. Research Proposed for '74, '75

The research program for fiscal '74 and '75 will be focussed specifically on developing integrated procedures for on-line decisionmaking of the sort appropriate for industrial or governmental agency decisions. General features of this process are: rapid response, geographically dispersed panels, interaction with data banks, and on-line modeling. Wherever feasible, development will be conducted in conjunction with relevant substantive studies, so that direct usefulness of the techniques will be apparent.

The program will consist of the simultaneous analysis of a relevant decision problem, and implementation of the components of the on-line decision process discussed above. A pertinent

example might be the generation of a decision model for budgetary
allocation across scientific fields. The exercise would consist
of (a) panel generation of research objectives, (b) panel rating
of relative importance of the objectives, (c) panel identification
of the major factors determining research productivity, (d)
compilation of an extensive data base on presently funded projects
structured according to the factors identified in "c", (e) panel
rating of a selected sample of projects in terms of their contribu-
tion to the objectives identified in "a", and an overall rating
in terms of scientific value, (f) test of a linear prediction
model of contribution to research objectives in terms of the
factors compiled in "d", on-line revision of judgments in light
of the results of the linear estimation.

This exercise would generate the evaluation "half" of the
budgetary model. The second phase of the exercise would consist
of the on-line generation of a set of budgetary alternatives,
assessment of the impact of each alternative on the factors "c",
and the computation of effect of each alternative on the research
objectives. This exercise could be accompanied by a control
portion, in which each panelist assessed directly his judgment of
the impact of each alternative on each research objective.

In order to conduct the Delphi exercise sketched above, almost
all of the capabilit. s mentioned would have to be implemented to
a significant extent.

REFERENCES

1. Lorge, Irving, David Fox, Joel Davitz, and Marlin Brenner, "A Survey of Studies Contrasting the Quality of Group Performance and Individual Performance," 1920-1957, Psychological Bulletin, Vol.55, No. 6, Nov. 1958, pp. 337-372.

2. Kelly, Harold H., and John W. Thibaut, "Experimental Studies of Group Problem Solving and Process," in Gardner Linsay, Ed., Handbook of Social Psychology, Addison-Wesley, 1954.

3. Dalkey, Norman C., "An Experimental Study of Group Opinion," Futures, Vol. 1, No. 5, Sept. 1969, pp. 408-426; and "Analyses From a Group Opinion Study," Futures, Vol. 1, No. 6, Dec. 1969, pp. 541-551.

4. Dalkey, Norman C. and Daniel L. Rourke, "Experimental Assessment of Delphi Procedures with Group Value Judgments," The RAND Corporation, R-612-ARPA, February 1971.

5. Williamson, John W., "Defining Universe of Health Professionals to Provide Prognostic Epidemiological Estimates," Johns Hopkins University, 1971.

6. Girshick, M., A. Kaplan, and A. Skogstad, "The Prediction of Social and Technological Events," Public Opinion Quarterly, Spring 1950, pp. 93-110.

7. Dalkey, Norman C., Samuel Cochran, and Bernice Brown, "Group Intelligence Measures," The RAND Corporation (in preparation).

8. Weaver, Timothy, "An Exploration into the Relationship Between Conceptual Level and Forecasting Future Events," Doctoral Dissertation, Graduate School of Syracuse University, 1969.

9. Gustafson, David H., et al., "A Comparative Study of Differences in Subjective Likelihood Estimates Made by Individuals, Interacting Groups, Delphi Groups and Nominal Groups," University of Wisconsin, Medical Decision Making Research Project, 1969.

10. Dalkey, Norman C., Bernice Brown, and Samuel Cochran, "The Delphi Method III: Use of Self Ratings to Improve Group Estimates," The RAND Corporation, RM-6115-PR, Nov. 1969.

11. Dalkey, Norman C., "The Delphi Method," The RAND Corporation, RM-5888-PR, June 1969.

12. Rokeach, Milton, "Race and Shared Belief as Factors in Social Choice," in Beliefs, Attitudes and Values, Jossey-Bass, 1968.

13. Dalkey, N., Daniel L. Rourke, and Bernice Brown, "Performance of Delphi Groups with Differential Information," The RAND Corporation, R-825-ARPA, 1972.

14. Brown, Thomas A., "An Experiment in Probabilistic Forecasting," The RAND Corporation, R-944-ARPA (in preparation).

15. Salancik, J. R., William Wenger, and Ellen Helfer, "The Construction of Delphi Event Statements," Technological Forecasting and Social Change, Vol. 3, No. 1, 1971, pp. 65-73.

16. Bavelas, Alex, "Communication Patterns in Task Oriented Groups," Journal of Accoustical Society of America, 1950, 22, 725-730; Guetzkow, Harold and Herbert Simon, "The Impact of Certain Communication Nets upon Organization and Performance in Task-Oriented Groups," Management Science, 1 April 1955, pp. 233-250; Shure, Gerald H., Miles S. Rogers, Ida M. Larsen, and Jack Tassone, "Group Planning and Task Effectiveness," Sociometry, Vol. 25, No. 3, September 1962, pp. 263-282.

17. McHale, John, "Typological Survey of Futures Research in the U. S.," Center for Integrative Studies, State University of New York at Binghamton, June 1970.

18. Anderson, Donald P., "Ohio State Study: Clarifying and Setting Priorities on an Intermediate School District's Objectives Utilizing the Delphi Technique," paper delivered at the American Educational Research Association meeting, March 4, 1970, Minneapolis, Minnesota.

19. Dalkey, N. C., "An Elementary Cross-Impact Model," Technological Forecasting and Social Change, Vol. 3, No. 3, 1972 (in publication).

20. Chambers, John C., Satinder K. Mullich, and David A. Goodman, "Catalytic Agent for Effective Planning," Harvard Business Review, January-February 1971.

21. Dalkey, Norman C., Ralph Lewis, and David Snyder, "Measurement and Analysis of the Quality of Life," The RAND Corporation, RM-6228-DOT, August 1970.

22. Dalkey, N., and O. Helmer, "An Experimental Application of the Delphi Method to the Use of Experts," Management Science, Vol. 9, No. 3, April 1963, pp. 458-467.

23. Turoff, Murray, "Delphi and Its Potential Impact on Information Systems," Office of Emergency Preparedness, Washington, D. C., 1971.

24. Umpleby, Stuart, "The Delphi Exploration," Computer-based Education Research Laboratory, University of Illinois, 1969.

25. Meeker, Robert J., Gerald H. Shure, and Alvin S. Cooperband, "An Implementation System for Designing Computer-Based Experiments," Proceedings, National Conference of the Association for Computing Machinery, 1971, pp. 169-178.

26. Cooperband, Alvin S., William H. Moore, Jr., Robert J. Meeker, and Gerald H. Shure, "TRACE-III: An Implicit Programming System for Inductive Data Analysis," Proceedings, National Conference of the Association for Computing Machinery, 1971, pp. 127-138.